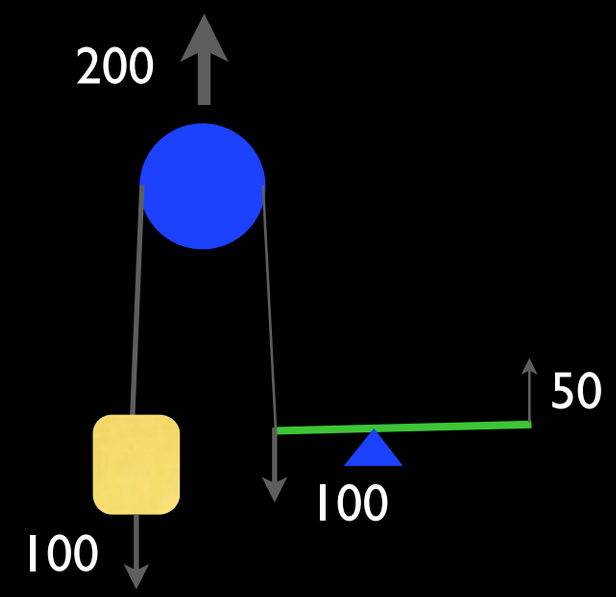
Physics and Body Mechanics for Suspension bondage

People are not objects

We can use physics to model and approximate suspension systems using people. But it is very important to remember that people are not static objects. They change with time and are capable of moving on their own. Both things that will eventually break any simple model.

The Physics

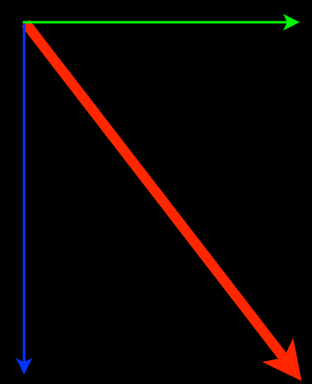
- Vectors
- Levers
- Pulleys



In simple newtonian mechanics we sue levers pulleys and vectors to describe what is going on with all the forces in a system.

Vectors

- Vectors are used to describe forces
- They describe magnitude of the force
- And they also describe the direction

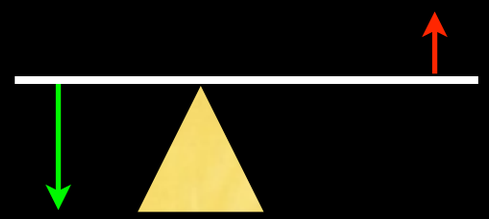


Vectors are a method of describing a force. The have a magnitude and a direction. The red arrow is a force vector. It can be drawn with a length depicting its magnitude or amount and a direction depicted by the pointed end of the arrow.

It is often useful to break a force vector up into orthogonal components. In this drawing the green vector and the blue vector add up to the red vector. So if we wanted to know how much of the red vector was acting from left to right we would use the green part or component.

Levers

- Levers Magnify Forces
- Levers have a pivot point or fulcrum
- Levers have a rigid member

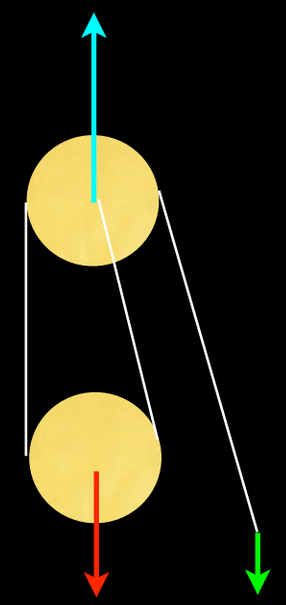


With levers the difference between the pivot point or fulcrum and the two forces determines how much force is needed on each end. A short lever has to use more force that a long one. But a long on has to travel farther to do the same amount of work.

The red and green vectors above are in balance with each other. The red force is smaller but has a longer lever arm and therefore needs less force to balance the green vector.

Block and Tackle

- Like levers block and tackle redirect and magnify forces.
- Often used for hoisting
- Friction can use up this advantage.

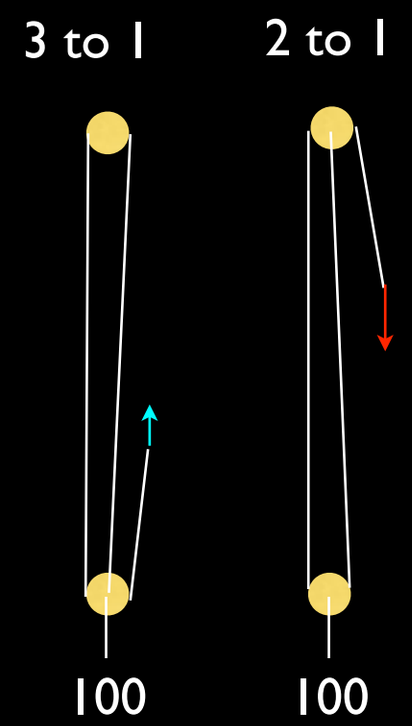


You can use an expensive block and tackle with ball bearings and rollers or you can simply run rope between two loops or carabiners to make a block and tackle. In the former you can assume almost no friction. When using the bight of your rope or a ring and carabiner friction will also reduce your advantage. Too many wraps and the friction will catch up and negate any advantage you gain.

In the diagram above the green vector is in balance with the red vector even though it is much smaller.

Lifting with Advantage

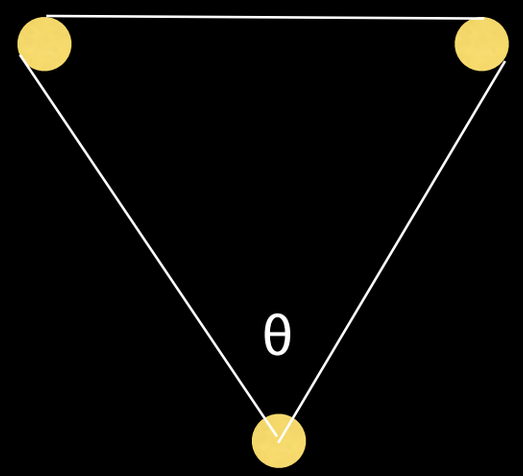
- Pulling on a line in the direction of the loads movement is more efficient.
- The force needed for the friction in the block and tackle helps move the load.



Planning how you set up your block and tackle can influence how much force you need. For the same 100 lb weight above the blue vector needs 33 lbs of force and the red vector need 50lbs of force.

Triangle of Death

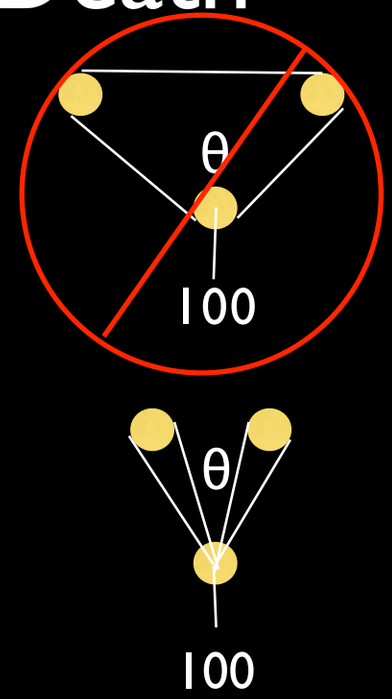
- As the angle increases the forces grow to be **greater** than the load.
- A good rule is to keep this angle below 60 degrees.



Using two points to rig form can spread the load out and make it safer. But done wrong it can actually make things more dangerous.

Triangle of Death

- Whenever you rig to two points rig from each separately.
- Keep the angle Theta as small as possible.
- This principle applies above and below the ring.



Triangle of Death

- The forces can add up fast.
- Table at right shows the force on EACH anchor for a 100 lb load

Angle θ	V Rig	Triangle
0°	50lb	71lb
30°	52lb	82lb
60°	58lb	100lb
90°	71lb	131lb
120°	100lb	193lb
150°	193lb	380lb

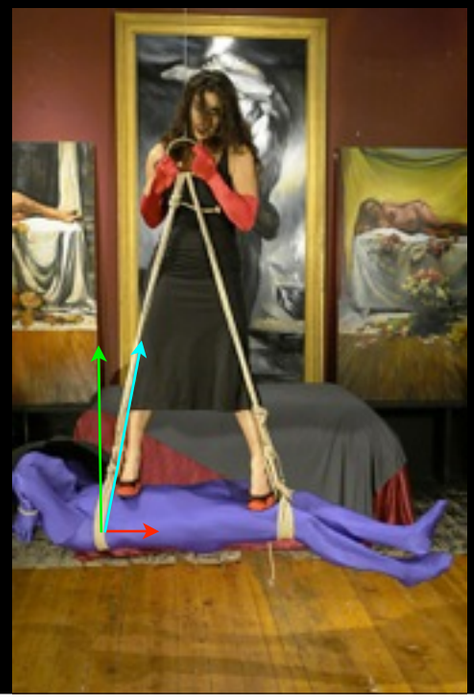
This table shows the results of the math. As you can see as the angle theta increases that load eventually gets “heavier” as far as the hard points are concerned. This is very dangerous and result in a bad catastrophic fall.

Beautiful and Wrong!!

This is an example of a very dangerous rigging. The forces on those hard points are double the models weight on each side.

Single Point Suspensions

- Narrower angles will decrease the compression forces along the torso
- There will always be some compression.
- No center line requires good core strength.



As the angle Theta increases the red vector will increase just like the other triangle. The red vector is trying to compress the models body length wise and can either bend the model or make the rope slip.

The smaller the angle up at the ring the less the red vector will be.

Example of a Lever

- An easy way to suspend a person is to use their own body as a lever.
- Doing this reduces the strength required to get someone up and DOWN.

Lift light body parts lower heavy body parts. Use the body like a lever.

Flexibility vs. Stability

- Joints that have more flexibility for more options for fun AND problems.
- Shoulders and spine are the joints most prone to injury.

You should always be aware of where the fulcrum is in other bondage also. In this case a small increase in the force at the models hands will translate in a large force at the models shoulders.

Stretching & Exercise

- Activities like yoga can increase flexibility in more stable joints, such as hips, without destabilizing them.

Box Arm Position

- Stretched Rotator Cuff and chest muscles
- Can assess before applying rope and correct with stretching.
- Many nerves & blood vessels can be impinged by chest muscles in this position.

Sustainability

- Pull shoulder straps out to decrease stress on collarbones.

Lack of Flexibility

- Find creative ways to be restrictive when a box arm tie is not possible.

Positional Stresses

- Leg up decreases tension on hips & lower back.
- Leg pulled down and back arched increased intensity.
- Gravity induces strappado position.

Small Adjustments

- Change the balance of the load or sustainability of a position with minor adjustments.
- Which leg to raise?
- Hips higher than chest, or not?

Harness Hang Syndrome

- Primarily occurs during vertical suspension.
- Caused by a lack of mobility in the legs.
- Symptoms: nausea; disorientation; fainting.
- Symptoms can arise in minutes.

Harness Hang Syndrome cont.

- Treatment: Generally the opposite of the treatment for shock.
- Keep person upright, seated or standing.
- Gradually introduce leg and foot movement to slowly recirculate blood.

Reversing the Curve

Reversing the Curve

- Balance out the body.
- Choose suspensions that reverse the effect of extreme positions.
- Can be part of play or aftercare stretching.

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